

CAREX ALBIDA (CYPERACEAE), AND ITS RELATIONSHIP
TO *CAREX LEMMONII*

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ABSTRACT

Carex lemmonii W. Boott is a widespread California endemic. Herbarium and field studies showed its extensive morphological variation included plants called *Carex albida* L. H. Bailey, previously considered endemic to Sonoma County, California. Due to extensive overlap, characters of the perigynium, achene, inflorescence, and foliage did not separate the two taxa. *Carex albida* becomes a synonym of the earlier name, *Carex lemmonii*, which has implications beyond nomenclature. *Carex lemmonii* is common and is not a conservation priority in California. When merged with *Carex lemmonii*, the only known natural population of *Carex albida* will no longer qualify for protection under federal and state endangered species legislation. A key and illustrations are provided for California species in *Carex* section *Aulocystis* Dumort.

Key Words: California, *Carex albida*, *Carex lemmonii*, Cyperaceae, endangered species.

Carex sect. *Aulocystis* Dumort. (syn. sect. *Ferrugineae* (Tuckerman) Kük.) is represented by eight species in North America, with five species recorded in California (Ball and Mastroguseppe 2002). One of these is *C. albida* L. H. Bailey, white sedge, restricted to Sonoma County, California. It was first collected on 1 May 1854, by Dr. Jacob M. Bigelow, expedition surgeon and botanist for Lieutenant Amiel W. Whipple's exploration for a railway route from the Mississippi River to the Pacific Ocean, near the 35th parallel of latitude (Torrey and Gray 1857, p. 154). References to George Thurber as a collector of *C. albida* (e.g., Boott 1880; Bailey 1889; Kükenthal 1909) are apparently an error, according to Howell (1957). Thus Bigelow was the only botanist to find *C. albida* in the 1800's, perhaps from present day Laguna de Santa Rosa (Best et al. 1996). There are only a couple additional locations from the 1900's (Howell 1957).

At present, plants called *Carex albida* are reduced to a single extant population in the diminished remnants of Pitkin Marsh wetlands, at an elevation of 30 m. The same site also supports a population of the Federally Endangered *Lilium pardalinum* Kellogg subsp. *pitkinense* (Beane & Vollmer) Skinner. *Carex albida* received protection as State Endangered under California legislation in November 1979. Federal listing as an Endangered Species came 22 October 1997 (62 FR 55791).

Carex lemmonii W. Boott, Lemmon's sedge, as traditionally defined, is a California endemic, known from 25 counties across the state, ranging in elevation from 700 to 3000 m (Consortium of

California Herbaria 2010). It favors creek banks, wet meadows, boggy meadows, fens, marshes, and peatlands, and occasionally is found on serpentine soils.

The type material of *Carex albida* was immature, and for many decades there were no additional collections. Eventually botanists questioned its taxonomic validity. Mackenzie (1922) combined *C. albida* with *C. luzulina* Olney. Later, Mackenzie (1935, 1940) lumped *C. albida* with *C. lemmonii*. However, his broad circumscription of *C. lemmonii* was not followed by Stacey (1937), who described *C. albida* again, as *C. sonomensis* Stacey. Howell (1957, 1965) included *C. sonomensis* within *C. albida*, while retaining *C. lemmonii* as a distinct species. His approach was followed by Mastroguseppe (1993) and then Ball and Mastroguseppe (2002). These different taxonomies were difficult to reconcile when preparing a treatment of *Carex* for the revision of the Jepson Manual (Mastroguseppe 1993; Zika et al. 2012). The purpose of this study was to evaluate the morphological characters various authors have used to discriminate between *C. albida* and *C. lemmonii*, and explain the revised classification presented here.

METHODS

The sedge literature was reviewed for morphological characters that separate *Carex albida* from *C. lemmonii*. The taxonomic concepts of the most recent treatment, Ball and Mastroguseppe (2002) served as a starting point. Characters of foliage, perigynia, achenes and inflorescences used in the literature over the last century were measured on

TABLE 1. A COMPARISON OF *CAREX ALBIDA* (INCLUDING THE TYPE OF *C. SONOMENSIS*) AND *C. LEMMONII* (INCLUDING THE TYPE OF *C. ABRAMSII*), WITH EMPHASIS ON CHARACTERS HISTORICALLY USED TO DISTINGUISH BETWEEN THE TWO TAXA. All specimens examined for *C. albida* are from Sonoma Co. (n = 39). All entries for the *C. lemmonii* column are from outside Sonoma County (n = 270). Achene length includes the stubby stipe at the base of the achene body, but does not include the irregular style remnants above the achene body.

Character	Taxon		Author using character
	<i>C. albida</i> (Sonoma Co.)	<i>C. lemmonii</i> (except Sonoma Co.)	
Dried leaf width (mm)	1.7–5.6	1.2–5.8	Mastrogiuseppe (1993); Ball and Mastrogiuseppe (2002)
Fresh leaf width (mm)	2–8 (cultivated)	1.5–6.5 (wild)	
Inflorescence length (cm)	2.5–37	5–49.2	Mastrogiuseppe (1993); Ball and Mastrogiuseppe (2002)
Inflorescence lowest internode (cm)	1–19	1.5–20	Mastrogiuseppe (1993)
Distal lateral spikes clustered	Y or N	Y or N	Kükenthal (1909); Stacey (1937); Howell (1957, 1965); Mason (1969)
Terminal spike overtops lateral spikes	Y, or slightly	Y, or slightly	Stacey (1937)
Sex of terminal spike (S = staminate; P = pistillate)	S, S/P, S/P/S, P/S, P	S, S/P, S/P/S, P/S, P	Stacey (1937); Howell (1965); Mason (1969); Mastrogiuseppe (1993)
Lateral spike length (mm)	5–15	6–22	Mastrogiuseppe (1993)
Scale color outside the green midrib	white, green, light brown, gold, sometimes red-brown splotches	white, green, light brown, gold, red-brown, sometimes dark purple splotches	Kükenthal (1909); Stacey (1937); Howell (1957, 1965); Mason (1969)
Perigynium color	green, light brown	green, light brown, sometimes red-brown or dark purple splotches	Howell (1957)
Perigynia (mm)	3.1–4.2 × 1.0–1.5(1.8)	(2.5)2.8–4.5(4.8) × (0.8)1.0–1.5(1.8)	Howell (1965); Mastrogiuseppe (1993)
Perigynium beak teeth bristly	Y or N	Y or N	Howell (1957)
Achene outline	obovoid, obovoid-elliptic, obovoid-oblong, ovate-elliptic, ovate-oblong, elliptic	obovoid, obovoid-elliptic, obovoid-oblong, ovate-elliptic, elliptic, broadly elliptic	Stacey (1937)
Achene (mm)	1.6–1.9 × 1.05–1.2	1.4–2.0 × 0.8–1.3	US Fish and Wildlife Service (2009)

herbarium specimens, using a micrometer and dissecting binocular microscope. Gatherings of *C. albida* (as well as its synonym *C. sonomensis*) and *C. lemmonii* (as well as its synonym *C. abramsii* Mack.), were studied at the following institutions: BM, CAS, CHSC, DS, F, G, GH, HSC, JEPS, K, MICH, MO, NY, ORE, OSC, NY, POM, RSA, S, UC, US, WILLU, WTU, and YM (acronyms from Holmgren et al. 1990).

All available types were scrutinized. This preliminary study utilized 39 herbarium specimens of *C. albida*, and 270 sheets of *C. lemmonii*. The range of variation for 13 characters, across all of California, was summarized in Table 1.

A principal components analysis (PCA) was performed in the R environment for statistical computing (R Development Core Team 2010). Ordination was performed using Euclidian distances. Non-metric multidimensional scaling

(NMS) was performed using PC-ORD (McCune and Mefford 2006), using Sorenson distances. The maximum number of iterations for the algorithm to perform was set to 200, however, the analysis reach a low-stress (10.25%) plateau after 83 iterations were performed. ANOVA, NMS, and PCA were based on a subset of 64 herbarium specimens, evaluating 18 morphological characters (Table 2). The vouchers are cited in Appendix 1; they included six isotypes, seven specimens of *Carex albida* and 57 specimens of *C. lemmonii* (Table 3). Sampled specimens came from 12 counties and six ecoregions in California (Baldwin et al. 2012).

Field visits were made to *Carex lemmonii* populations in Butte, Mariposa, and San Bernardino counties in 2009 and 2010. Leaf width was measured fresh on ten cultivated plants of *C. albida* at the Botanical Gardens of the University

TABLE 2. THE 18 MORPHOLOGICAL CHARACTERS EVALUATED FOR ANOVA, PCA AND NMS ANALYSES.

Morphological character
Width of narrowest basal leaf (mm)
Width of widest basal leaf (mm)
Stem height (cm)
Inflorescence length (cm)
Length of proximal inflorescence internode (cm)
Clustering of distal spikes (yes or no)
Distance from apex of distal lateral spike to apex of terminal spike (mm)
Sex of terminal spike
Length of shortest lateral spike (mm)
Length of longest lateral spike (mm)
Color of pistillate scales (whitish-green, red-brown, dark purple)
Color of perigynia (whitish-green, red-brown, dark purple)
Length of perigynium (mm)
Width of perigynium (mm)
Perigynium beak teeth with bristles (yes or no)
Distance from achene apex to perigynium beak apex (mm)
Length of achene body (not including stipe or beak; mm)
Width of achene body (mm)

of California in Berkeley, in November 2009. Corresponding measurements were made on living plants of *C. lemmonii* in meadows along the South Fork of the Santa Ana River in San Bernardino County in August 2010. Vouchers of *C. lemmonii* were deposited at CHSC, JEPS, MICH, OSC, RSA, and WTU.

RESULTS

Taxonomists often use perigynium differences to separate closely related *Carex* species. Photographs of the perigynia of each California member of sect. *Anlocystis* are shown in Fig. 1. Typical *C. lemmonii* perigynia (Fig. 1A–E) show

variation in length, width, outline, color, streaking, and marginal bristles. Each sample of 4–5 perigynia was derived from a single herbarium specimen. With practice, *C. lemmonii* perigynia are distinguishable from *C. luzulina* (Fig. 1G) by beak length and color differences. *Carex luzulifolia* S. Watson perigynia (Fig. 1F) have broader wings and longer, narrower, more abrupt beaks than *C. lemmonii*. *Carex fissuricola* Mack., with perigynia somewhat intermediate between *C. luzulina* and *C. luzulifolia*, is separable by its stiff spreading-ascending bristles just visible as a sparse white fuzz (Fig. 1H). In summary, typical perigynia of *C. luzulina*, *C. luzulifolia*, and *C. fissuricola* look different from typical perigynia of *C. lemmonii*, as shown in Fig. 1. But within *C. lemmonii* plants from Sonoma Co. (Fig. 1A) are not distinguishable from specimens from Mariposa Co. (Fig. 1B). Perigynia from the types of *C. sonomensis* (Fig. 1A) and *C. abramsii* (Fig. 1E) merge imperceptibly with perigynia of *C. lemmonii* from elsewhere across the California floristic province.

This pattern of overlap was also true for the other features measured. A detailed examination of critical morphological characters, including foliage, inflorescences, spikes, scales, achenes, and perigynia, is collated in Table 1. The preliminary study did not find any character that discriminates between *Carex albida* and *C. lemmonii*. The most extreme difference was leaf width, which was reported to be slightly greater in *C. albida* than in *C. lemmonii* (Mastrogioseppe 1993; Ball and Mastrogioseppe 2002). Leaf width was found to decrease when specimens were dried, and was too variable between individuals to be useful (Table 1). Even with fertilizer treatments, several cultivated plants of *C. albida* had widest (fresh) leaves 5–5.5 mm, while other garden plants had fresh leaves 7–8 mm wide. Within this continuum fit wild plants in the San Bernardino Mountains, with widest fresh leaves 4–6.5 mm wide. Not all

TABLE 3. GEOGRAPHIC ORIGIN AND NUMBER OF HERBARIUM SPECIMENS OF *CAREX LEMMONII* AND ITS SYNONYMS FROM CALIFORNIA EXAMINED FOR ANOVA, PCA AND NMS ANALYSES IN THIS STUDY. See Appendix for a list of vouchers. County distribution: AL = Alpine Co., BU = Butte Co., EL = El Dorado Co., FR = Fresno Co., MA = Mariposa Co., NE = Nevada Co., PL = Plumas Co., SA = San Bernardino Co., SI = Sierra Co., SO = Sonoma Co., TU = Tulare Co., YU = Yuba Co. Ecoregion distribution (Baldwin et al. 2012): CaR = Cascade Range, NCoRO = Outer North Coast Ranges, n SN = northern Sierra Nevada, c SN = central Sierra Nevada, s SN = southern Sierra Nevada, SnBr = San Bernardino Mountains.

<i>Carex</i>	California counties											
	AL	BU	EL	FR	MA	NE	PL	SA	SI	SO	TU	YU
<i>C. abramsii</i> isotype								1				
<i>C. sonomensis</i> isotypes										5		
<i>C. lemmonii</i>	1	23	1	2	3	2	16	4	1	2	1	2
	California ecoregions											
	CaR	NCoRO	n SN	c SN	s SN	SnBr						
All <i>Carex</i> combined	13	7	31	5	3	5						

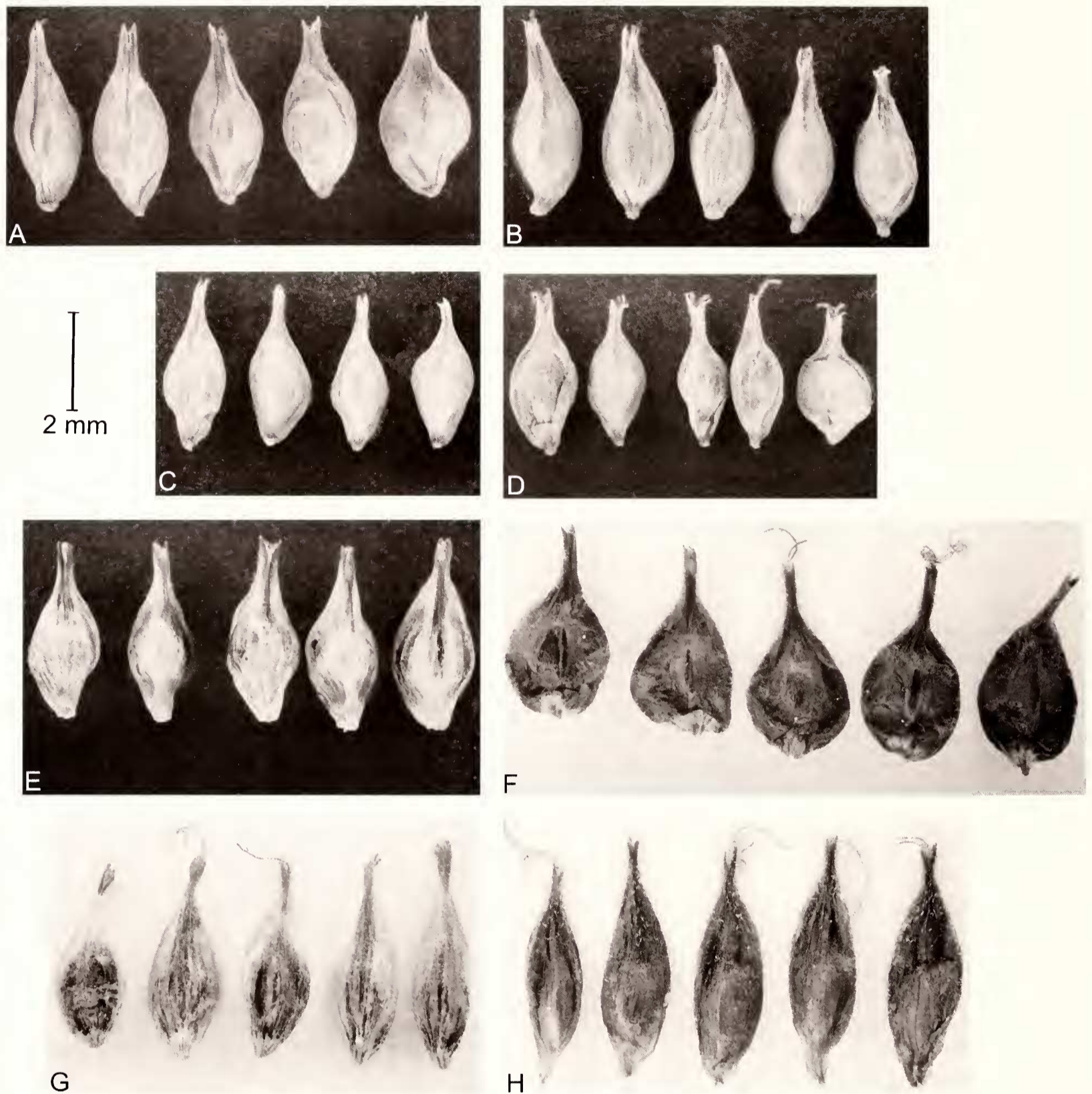


FIG. 1. Representative perigynia for *Carex* sect. *Aulocystis*, all specimens from California. A. *Carex lemmonii* from Sonoma County, an isotype of *C. sonomensis* (J. T. Howell & Stacey 13042). B. *Carex lemmonii* from Mariposa County (Bolander 4995). As in A, note large pale perigynia. C–D. *Carex lemmonii* from two different populations in Butte County. C. (Copeland s.n.). D. (Janeway 3039 & Schlising). E. *Carex lemmonii* from San Bernardino County, an isotype of *C. abramsii* (Abrams 2816). Note some dark purple blotches. F. *Carex luzulifolia* from Tuolumne County (Cohwell 5-361 & Grossenbacher). Note broad flat wing around achene and narrow straight-sided beak. G. *Carex luzulina* from Del Norte County (Tracy 19177). Note beaks slightly longer and color slightly darker than *C. lemmonii*. H. *Carex fissuricola* from Fresno County (J. T. Howell 22451). Note pale bristles on distal perigynium surfaces.

plants from Sonoma County have broad leaf blades. Given the variation within populations, we did not consider leaf width to have any practical taxonomic significance between populations. Additional statistical analysis was used to address this question, as discussed below.

Field visits to *Carex lemmonii* populations from Butte, Mariposa, and San Bernardino counties showed broad variation in many char-

acters. A number of individuals were observed in the field that closely resembled herbarium specimens as well as cultivated plants of *C. albida*, in habit, and in technical details (Table 1).

Quantitative Analysis

An ANOVA of quantitative morphological traits found that *Carex albida* specimens did not

TABLE 4. SELECTED QUANTITATIVE MORPHOLOGICAL TRAITS IN *CAREX ALBIDA* (N = 7) AND *C. LEMMONII* (N = 57). All *C. albida* specimens are from Sonoma Co., all *C. lemmonii* specimens are from other counties in California.

Trait (unit of measurement)	<i>C. albida</i>		<i>C. lemmonii</i>	
	mean (s.e.)	range	mean (s.e.)	range
Leaf width, minimum (mm)	2.6 (0.16)	2.0–3.1	1.8 (0.06)	0.9–2.8
Leaf width, maximum (mm)	4.8 (0.42)	3.2–5.9	3.2 (0.10)	1.8–5.5
Culm height (cm)	62.8 (4.15)	44.9–73.3	60.5 (2.64)	27.7–114.7
Inflorescence length (cm)	19.3 (2.57)	12.0–30.0	17.5 (1.20)	5.6–52.8
Lowest infl internode length (cm)	14.0 (2.00)	9.2–24.8	10.5 (0.65)	2.8–24.1
Distance between distal-most 2 spikes (mm)	10.1 (1.50)	6.0–8.0	8.3 (0.39)	2.0–17.0
Lateral spike length, minimum (mm)	7.3 (0.47)	6.0–9.0	7.7 (0.25)	4.0–12.0
Lateral spike length, maximum (mm)	11.3 (1.30)	8.0–17.0	12.0 (0.41)	7.0–20.0
Perigynium length (mm)	3.7 (0.08)	3.4–4.0	3.5 (0.05)	2.8–4.5
Perigynium width (mm)	1.3 (0.03)	1.2–1.4	1.3 (0.03)	0.9–1.7
Perigynium beak length (mm)	1.6 (0.08)	1.5–1.7	1.5 (0.04)	0.9–2.2
Achene length (mm)	1.5 (0.06)	1.4–1.8	1.5 (0.02)	1.2–1.8
Achene width (mm)	1.1 (0.02)	1.1–1.2	1.1 (0.02)	0.7–1.4
Perigynium length/width	2.8 (0.10)	2.5–3.2	2.8 (0.06)	1.9–3.8
Achene length/width	1.3 (0.05)	1.2–1.6	1.4 (0.03)	1.1–1.8
Beak length/perigynium length	0.4 (0.012)	0.4–0.5	0.4 (0.01)	0.3–0.5

differ from *C. lemmonii* specimens ($F = 0.2732$, $P = 0.9999$). Except for leaf width, measured morphological traits of the seven Sonoma specimens were within the range for the 57 measured *C. lemmonii* specimens (Table 4). The widest leaves observed were found in *C. albida* specimens and if that trait were considered alone the difference between the taxa would be considered significant ($t = 3.721$ and 4.979 for minimum and maximum leaf width respectively, $P = 0.001$ and 0.007 , respectively). But there was considerable

overlap of leaf width with *C. lemmonii*, as discussed above (Tables 1, 4). Green scale color was more common in *C. albida* than in *C. lemmonii*, but occurred in both (Tables 1, 5). Gynecandrous terminal spikes were observed in three of the seven *C. albida* and not in the *C. lemmonii* specimens, but the other arrangements observed in *C. albida* were found in *C. lemmonii* (Table 5). Our more extensive sample of *C. lemmonii* did yield occasional gynecandrous terminal spikes (Table 1), so we do not believe

TABLE 5. SELECTED QUALITATIVE TRAITS IN *CAREX ALBIDA* (N = 7) AND *C. LEMMONII* (N = 57). All *C. albida* specimens are from Sonoma Co., all *C. lemmonii* specimens are from other counties in California (S = staminate portion of spike; P = pistillate portion of spike).

Trait	<i>C. albida</i>	<i>C. lemmonii</i>	<i>C. albida</i>	<i>C. lemmonii</i>
	number	number	percent	percent
Scale color				
green	6	23	86%	40%
red-brown	1	24	14%	42%
purple	0	10	0%	18%
Terminal spikes				
clustered	6	42	86%	74%
not clustered	1	15	14%	26%
Terminal spikes				
staminate	2	48	29%	84%
S/P	1	8	14%	14%
S/P/S	1	1	14%	2%
P/S	3	0	43%	0%
Perigynium color				
green	6	29	86%	51%
red-brown	1	8	14%	14%
purple	0	20	0%	35%
Perigynium beak teeth bristly				
no	3	30	43%	53%
yes	4	27	57%	47%

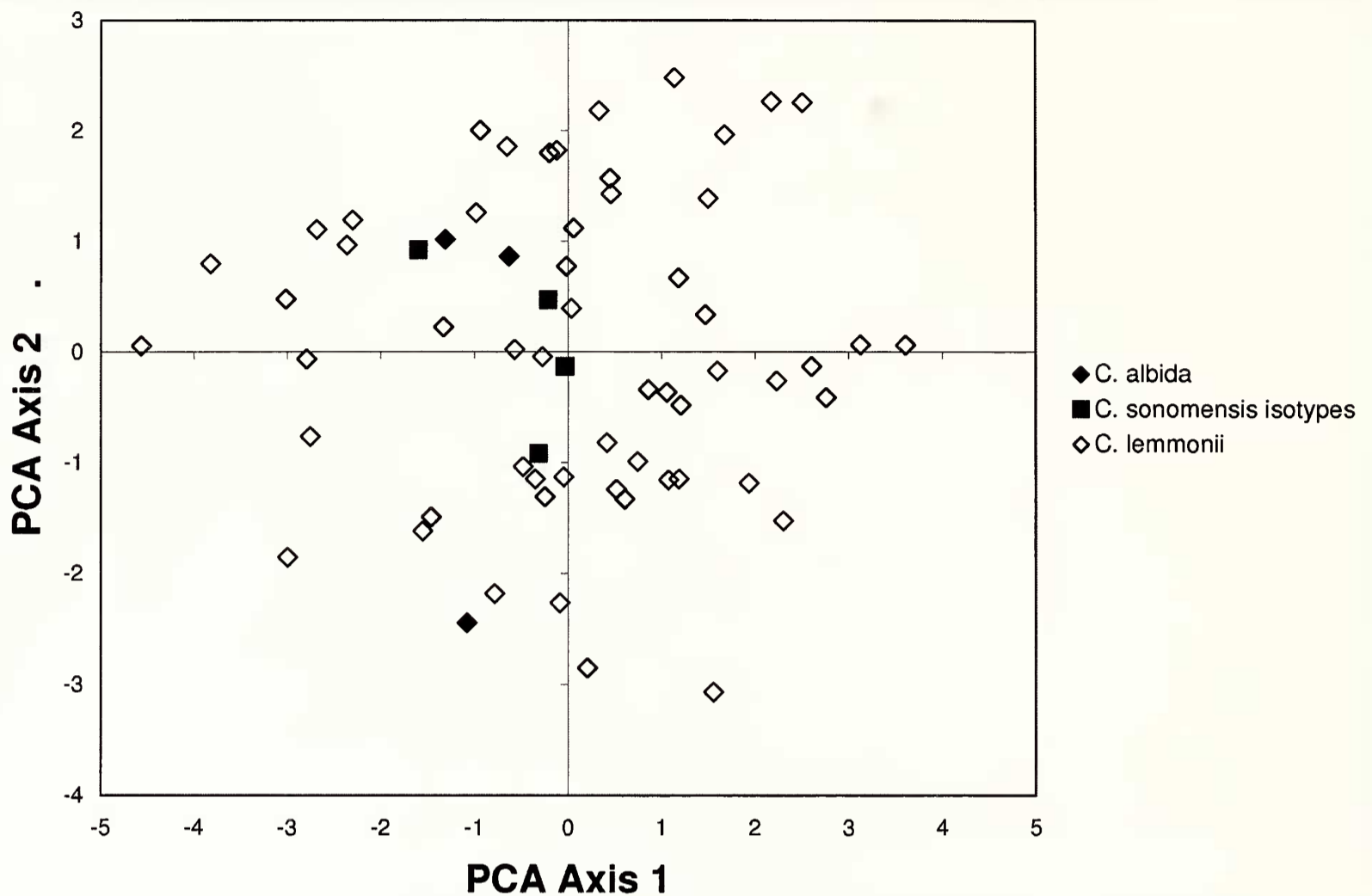


FIG. 2. PCA of 10 quantitative traits in *Carex albida* ($n = 7$) and *C. lemmonii* ($n = 57$). All *C. albida* specimens are from Sonoma County, all *C. lemmonii* specimens are from other counties in California. See Table 5.

this character has any definitive taxonomic significance, contrary to previous authors (Stacey 1937; Howell 1965; Mason 1969; Mastrogioseppe 1993).

Carex albida specimens clustered with *C. lemmonii* in the PCA (Fig. 2). In this analysis, PCA axis one is related to plant size, axis 2 to the size and shape of the perigynium and achene, and axis 3 to leaf width and inflorescence size (Table 6). Together, these axes explain 58% of the variation in the data. Certain morphological traits were omitted from the analysis because they

were closely, causatively related (e.g., achene width with achene length/width ratio, or minimum and maximum leaf width). Similar results were obtained with the full data set (results not shown). Results of NMS that included qualitative traits (Table 5) as well as quantitative traits gave similar results (not shown).

DISCUSSION

Critical perigynium features (Fig. 1), selected morphological characters (summarized in Table 1),

TABLE 6. FACTOR LOADINGS FOR THE FIRST THREE COMPONENTS IN PRINCIPLE COMPONENTS ANALYSIS (PCA) OF 10 QUANTITATIVE TRAITS IN *CAREX ALBIDA* ($N = 7$) AND *C. LEMMONII* ($N = 57$). The proportion of variance explained by each axis is 0.294 (Axis 1), 0.184 (Axis 2), and 0.105 (Axis 3). All *C. albida* specimens are from Sonoma Co., all *C. lemmonii* specimens are from other counties in California. See Fig. 2.

Loadings	Axis 1	Axis 2	Axis 3
Leaf width, maximum (mm)	-0.262		0.589
Culm height (cm)	-0.465	0.104	-0.142
Inflorescence length (cm)	-0.360		-0.512
Distance between distal spikes (mm)	-0.181	-0.118	0.291
Lateral spike length, minimum (mm)	-0.346	0.131	
Lateral spike length, maximum (mm)	-0.424		-0.247
Perigynium length (mm)	-0.377	-0.340	0.304
Achene length (mm)	-0.207	-0.541	
Perigynium length/width	0.123	-0.554	
Achene length/width	0.228	-0.481	-0.229

as well as statistical testing with ANOVA, PCA, and NMS all fail to distinguish *Carex albida* from *C. lemmonii* in the herbarium and in the field. In short, we can find no reason to retain *C. albida* as a distinct species. We agree with Mackenzie (1935, 1940) who combined *C. albida* and *C. lemmonii* with the note that *C. albida* "is based on very young and poor material, and apparently is best placed under this species." Review of the ample collections of the type of *C. sonomensis* in excellent fruiting condition support this conclusion. *Carex lemmonii* collections and populations we have seen from Butte, Plumas and San Bernardino counties are very similar to plants from Sonoma County, and at times indistinguishable.

The oldest name in the complex is *Carex lemmonii*. The relevant nomenclature and synonyms are provided below. *Carex albida* should be synonymized under *C. lemmonii*, and *C. albida* should be removed from state and federal endangered species lists. A distribution map for *C. lemmonii* was prepared based on all verified herbarium records (Fig. 3). It includes plants from the Coast Ranges in Glenn, Lake, and Sonoma counties.

TAXONOMY

Carex lemmonii W. Boott, Botanical Gazette 9: 93. 1884 (see Fig. 1B, C, D in this paper).—Type: [USA, California], 1875, *J. G. Lemmon s.n.*, Ex Herb. William Boott (holotype: GH 57537!; isotype: US 29211!).

Carex albida L. H. Bailey, Memoirs of the Torrey Botanical Club 1: 9. 1889.—Type: [USA], California, Santa Rosa Creek, Lieut. A. W. Whipple's Exploration for a railway route, from the Mississippi River to the Pacific Ocean, near the 35th parallel of latitude, in 1853–1854, [1 May 1854], *Dr. J. M. Bigelow s.n.*, surgeon and botanist to the expedition (holotype: NY 25089 in part!; isotypes: GH 277342!, K 710288 in part, ex herb. Hooker!, K 710288 in part, ex herb. W. Boott!, NY 25090 in part!).—*Carex luzulifolia* W. Boott forma *albida* (L. H. Bailey) Kük., Das Pflanzenreich Heft 38, 4(20): 558. 1909.

Carex abramsii Mack., Bulletin of the Torrey Botanical Club 36: 482. 1909.—Type: USA, California, San Bernardino Co., San Bernardino Mountains, in cienega between Bear Valley and Bluff Lake, 31 Jul 1902, *L. R. Abrams 2816* (holotype: NY 38976!; isotypes: CAS 162047!, DS 55317!, DS 180490!, F 186491!, POM 156062!).

Carex sonomensis Stacey, Leaflets of Western Botany 2: 63. 1937.—Type: USA, California, Sonoma Co., Pitkin Marsh, 6 Jun 1937; *J. T. Howell & J. W. Stacey 13042* (holotype: CAS 246086!; isotypes: CAS 246636!, F

907841!, G 191533!, GH 27438!, MICH 1109192!, NY 11335!, POM 230328!, RSA 90882!, S (S-G9509)!, UC 835699!, 147785!, US 3163254! US 1736782, n.v., WTU 11837!).

Key to California Members of *Carex* Sect. *Aulocystis*

Perigynium beak length can provide a useful comparative index for some members of *Carex* sect. *Aulocystis*. The traditional method of assessing perigynium beak length in *Carex* measures the distance from the beak tip to the inflection point, where the curve of the perigynium body transitions into the curve of the beak. The inflection point is easy to see in Fig. 1F, but is difficult to determine for other species in sect. *Aulocystis*, where the taper to the beak is gradual or asymmetrical, not abrupt (Fig. 1G, H). An alternative method, used by Ball and Mastroggiuseppe (2002), is to measure the distance from the beak tip to achene tip (the summit of the achene body), which sometimes requires dissection of the perigynium surface. The key below uses this method. This measurement is generally longer than the traditional beak length distance. The varieties of *C. luzulina* recognized by Ball and Mastroggiuseppe (2002) and Dorn (1988) are not recognized here.

1. Perigynium faces, at least near the beak, pubescent with hairs or stiff bristles; distal margins of scales or midvein ciliate or glabrous
2. Perigynium faces, at least near the beak, with sparse, spreading-ascending, short stout-based stiff bristles, similar to the bristles on the margin of the beak; distal margins of scales or midvein ciliate. *C. fissuricola*
- 2'. Perigynium faces, at least near the beak, with sparser, spreading or appressed, short thin-based, weaker hairs, differing from the bristles on the margin of the beak; distal margins of scales or midvein glabrous or ciliate. rare forms of *C. luzulina*
- 1'. Perigynium faces glabrous; distal margins of scales and midvein glabrous
3. Perigynia broadly winged and flat around achene, flat margin more than 1/2 the width of the mature achene; perigynia 1.7–2.5 mm wide; inflorescence bract sheath expanded towards the shallow U-shaped mouth, (1.8)2.0–3.0 mm wide at mouth. *C. luzulifolia*
- 3'. Perigynia narrowly winged or wingless and plump, flat margin absent or less than 1/2 the width of the mature achene; perigynia 0.9–2.0 mm wide; inflorescence bract sheath not (or only slightly) expanded towards the shallow Y- or V-shaped mouth, 0.6–2.0 mm wide at mouth
4. Distance from achene tip to perigynium beak tip usually ≤ 1.6 mm; scales and perigynia usually white, green, or red-brown over a green background,

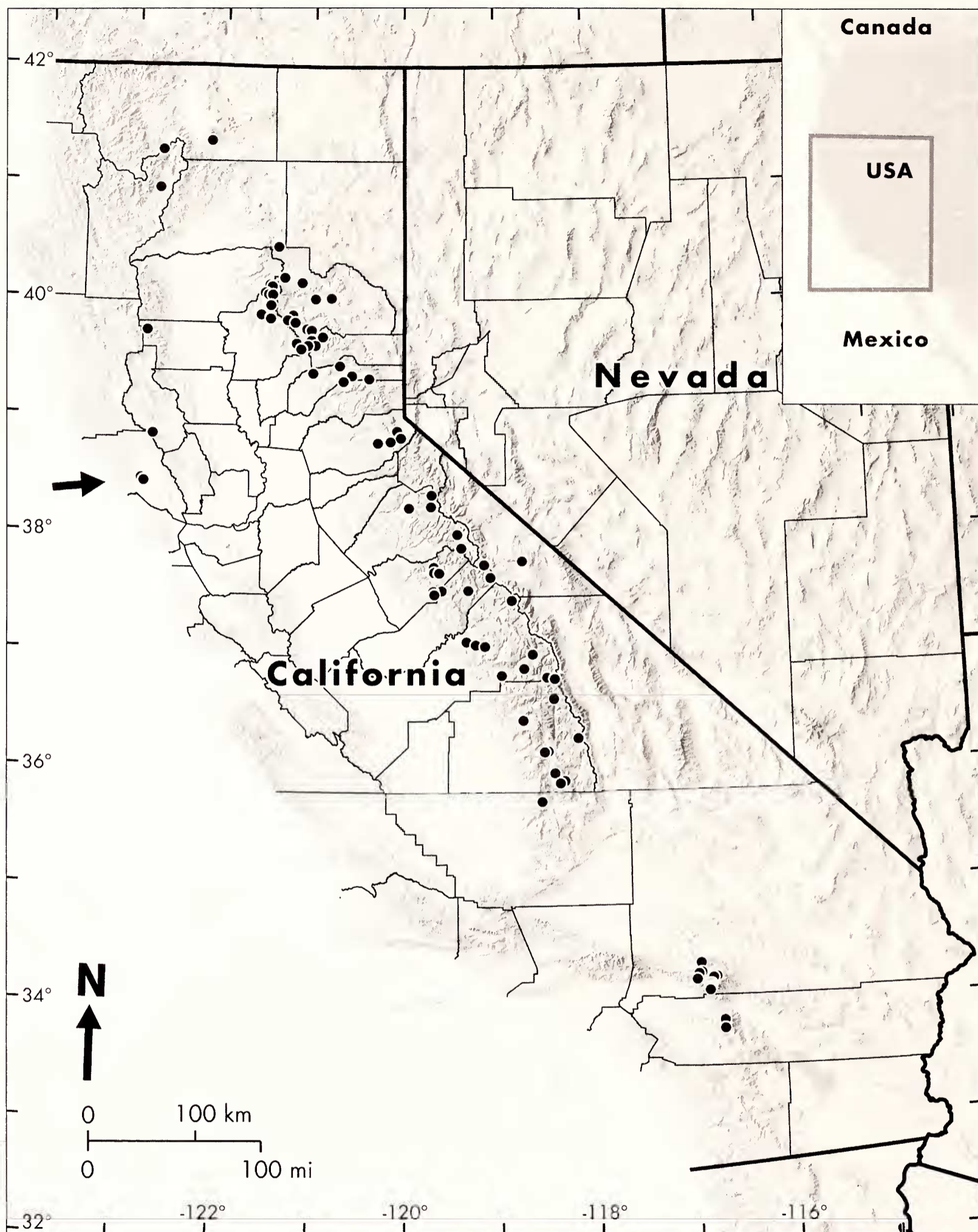


FIG. 3. Distribution map of *Carex lemmonii* in California based on herbarium specimens. Sonoma County collections indicated with arrow.

in some populations occasionally marked with dark purple . . . *C. lemmonii*

- 4' Distance from achene tip to perigynium beak tip usually ≥ 1.8 mm; scales and perigynia usually red-brown to dark purple over a green background *C. luzulina*

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APPENDIX 1

SPECIMENS EXAMINED

Herbarium acronyms from Holmgren et al. (1990). Each specimen included in ANOVA, PCA and NMS analyses, as well as Fig. 3.

***Carex abramsii* Mack. Isotype.** USA. CALIFORNIA. **San Bernardino Co.:** Bear Valley, 31 Jul 1902, *L. Abrams 2816* (F).

***Carex lemmonii* W. Boott.** USA. CALIFORNIA. **Alpine Co.:** W side Sonora Pass, 2347 m, 3 Aug 1944, *J. T. Howell 19873* (G). **Butte Co.:** Jonesville, bog, 5 Jul 1929, *Copeland 610* (ORE); Jonesville, meadow below the cabin, 1523 m, 25 Jul 1930, *Copeland 1362* (G); near Scout Rd, 1.2 mi N of Butte Meadows, 1325 m, 6 Jul 1983, *Oswald 825* (CHSC); Cherry Hill Meadow, 3.2 mi E of Butte Meadows, 1414 m, 24 Jul 1983, *Morey 623* (CHSC); Chico Meadows, 1292 m, 4 Aug 1983, *Morey 704* (CHSC); seep 3 road mi S of Big Bar Mountain, 1021 m, 8 Jun 1987, *Janeway 2182* (ORE); meadow just NE of junction of Concow Rd and road to Flea Mountain, 1188 m, 13 Jun 1987, *Janeway 2215* (CHSC); Barton Hill Rd 1.7 mi from Challenge-LaPorte Road, 1066 m, 19 Jun 1987, *Janeway 2244* (CHSC); 1 mi SW

of Jones Meadow, 1798 m, 5 Jul 1987, *Janeway 2449* (CHSC); junction of Philbrook Rd and Humboldt Summit Rd, 1554 m, 5 Jul 1987, *Janeway 2467* (ORE); meadow, upper reach of Brush Creek, 952 m, 2 Jul 1988, *Janeway 2946* (CHSC); Scotts John Creek 2.7 mi N of Butte Creek road, 1920 m, 23 Jul 1988; *Janeway 3086 & Schlising, Castro* (CHSC); meadow, SE side of Humbug Summit Road, at Cornelia Lott Sank Memorial Spring, 1519 m, 13 Jul 2003, *Janeway 7902* (MICH); Pinkard Creek ca. 1.5 mi N of Lost Creek Reservoir, 1067 m, 17 Jun 1988, *Oswald & Ahart 3403* (CHSC); dirt road to Forbestown Reservoir, ca. 2.5 mi NE of Forbestown, 868 m, 30 Jun 1985, *Ahart 5078* (CHSC); E side of West Branch Feather River, 4 road mi N of Stirling City, 914 m, 31 Jul 1988, *Ahart 6145* (CHSC); ca. 0.25 mi W of Lost Creek Reservoir, 1036 m, 26 Jun 1993, *Ahart 7007* (CHSC); bog on N side of road to Big Kimsheew Creek, 1.5 mi SE of Bald Mountain, 1493 m, 31 Jul 1993, *Ahart 7137* (CHSC); Paradise Lake, 790 m, 3 Jul 1997, *Hrusa 13964 & Wilfred* (CHSC); Snow Meadow, about 0.25 mi E of Table Mountain, 1523 m, 1 Aug 1997, *Ahart 7777* (CHSC); upper W branch of Know-nothing Creek, 4 air mi NE of Feather Falls, 1219 m, 11 Jul 2000, *Ahart 8569* (CHSC); Watson Ridge, 1.7 air mi NNW of Feather Falls Overlook, 1133 m, 21 Jun 2002, *Dittes 616 & Guardino* (CHSC); Concow Rd 11.5 road mi N of Route 70, at Dixie Rd, 1210 m, 17 Jun 2009; *Zika 24519* (OSC). **El Dorado Co.:** Kings Meadow, near headwaters of Slab Creek, 1359 m, 23 Jul 2006, *Janeway 8861* (CHSC). **Fresno Co.:** Bubbs Creek Canyon near Vidette Meadows, 2896–3048 m, 22 Jul 1948, *J. T. Howell 24888* (S); Converse Basin, 2.1 air km NNW of Cherry Gap, 1939 m, 6 Jul 2003, *Janeway 7876* (CHSC). **Mariposa Co.:** Yosemite National Park, logging road S of Crane Flat Campground, near park boundary, 1860 m, 30 Jun 2005, *Cohwell AC05-44* (YM); Yosemite National Park, meadow just W of Crane Flat, 1829 m, 16 Jun 1940, *Sharsmith 4165* (YM); Yosemite National Park, above Glacier Point Road, ca. 3.3 road mi NE of Chinquapin, 2120 m, 19 Aug 2010, *Zika 25376 et al.* (WTU). **Nevada Co.:** Tahoe National Forest, tributary of Texas Creek; ca. 1 mi W of Bowman Mtn., 0.8 mi N of Loney Meadow, 1899 m, 14 Jul 1997, *Janeway 5214 & Schroder* (OSC). **Plumas Co.:** Lassen Volcanic National Park, near Soda Spring, Drakesbad, 1676–1829 m, 23 Jul 1960, *J. T. Howell 35946* (OSC); Lassen Volcanic National Park, Drakesbad, 18 Jul 1960, *J. T. Howell 35513* (OSC); SW of Bucks Lake, near Grizzly Creek Campground, 1585 m, 13 Jul 1984, *Janeway 904* (CHSC); ravine on N side of South Branch Middle Fork Feather River, below Whiskey Hill, 1158 m, 20

Jun 1987, *Janeway 2283* (CHSC); unnamed W fork of Mohawk Creek, near Clio, 1585 m, 17 Jul 1987, *Janeway 2488 & Castro* (CHSC); N branch of Consignee Creek, Rd 23N49, 4.3 mi SE of Jackson Creek campground, 1737 m, 13 Jul 1989, *Janeway 3491* (CHSC); halfway between Paradise Creek and Emigrant Creek, 2/3 mile S of Little Grizzly Creek, 1875 m, 11 Jul 1990, *Janeway 3785* (CHSC); head of W branch of Stag Creek, Rd 22N80Y, 0.3 mi SSE of Table Mountain, 1756 m, 23 Jul 1995, *Janeway 4869* (CHSC); upper N branch of Spanish Creek, ca. 1.1 km NE of Maple Flat, 1609 m, 7 Jul 2000, *Janeway 6882* (CHSC); upper end of Rock Island Ridge, head of a W tributary of Toland Creek, 1576 m, 4 Jul 2009, *Janeway 9843 & Castro* (WTU); E side of Sly Creek, ca. 1 mi N of Schwartz Meadow, 1 mi E of Sly Creek Reservoir, 1097 m, 17 Jun 1994, *Ahart 7348* (CHSC); bog or wet meadow, c. 2 air mi W of Tamarack Flat, 4 air mi NW of Little Grass Valley Reservoir, 1648 m, 9 Jul 2006, *Ahart 12914* (CHSC); headwater of Clear Creek, ca. 2 air mi N of Butt Valley Reservoir Dam, 1476 m, 13 Jul 2009, *Ahart 16032 & Dittes* (WTU); Butterfly Valley Botanical Area, 1158 m, 17 Jun 2004, *Hrusa 16290 et al.* (CHSC); Butterfly Valley, 1096 m, 12 Jun 1967, *Rose 67151* (MICH); McRae Meadow, 1981 m, 27 Jun 1951, *J. T. Howell 27597* (K). **San Bernardino Co.:** Dollar Lake Trail, San Bernardino Mts., 2819 m, 23 Jul 1947, *Munz 12001* (WTU); Dollar Lake Trail, 3167 m, 23 Jul 1947, *J. T. Howell 23563* (K); Sugarloaf Meadow area, 17 Aug 2010, *Gross 5305 & Zuniga* (WTU); South Fork Meadows, along South Fork Santa Ana River, 2500 m, San Gorgonio Wilderness Area, San Bernardino National Forest, San Bernardino Mountains; 5 Aug 2010; *Zika 25290 et al.* (WTU). **Sierra Co.:** dirt road N of Pacific Mine, ca. 5 mi E of LaPorte, 1700 m, 28 Jul 1982, *Ahart 3725* (CHSC). **Sonoma Co.:** Pitkin Marsh, near Forestville, W branch of Upper Marsh, 5 Aug 1951, *Rubtzoff 602* (G); Pitkin Marsh, 13 Jun 1957, *J. T. Howell s.n.* (MICH). **Tulare Co.:** Sequoia National Forest, headwaters meadow of Freeman Creek, Forest Service Rd 20S75, 1.5 mi N of Woodys Pack Station, 2316 m, 3 Jul 1974, *Shevock 3710* (MICH). **Tuolumne Co.:** 4 mi W of Lake Eleanor Reservoir, Crane Meadow, 12 Jul 1948, *Quick 48–39* (G). **Yuba Co.:** stream E of Schwartz Meadow, E of La Porte Road, ca. 4 mi NE of Strawberry Valley, 1219 m, 27 Jun 1994, *Ahart 7387* (CHSC); stream and meadow 50 m W of Fountain Hill Road, ca. 5 air mi N of Dobbins, 837 m, 6 Jul 2003, *Ahart 10360* (CHSC).

Carex sonomensis Stacey. **Isotypes.** USA. CALIFORNIA. **Sonoma Co.:** Pitkin Marsh, 6 Jun 1937, *J. T. Howell & J. W. Stacey 13042* (F, G, MICH, S, WTU).